Air Quality

I. Health Issues

While air pollution and air quality are inextricably linked since the era of the industrial revolution, recent studies have revealed a quantitative correlation between specific air pollutants on the one hand, and human health and mortality rates on the other (e.g. Pope et al. 1995, Saldina et al. 1995, Seaton et al. 1995, Anderson et al. 1996, McMichael et al. 1996, Katsouyanni et al. 1996, WHO 2000 Guidelines for Air Quality).

On top of the industrial emissions, in urban areas all vehicular emissions can be considered quite damaging to public health. The health impact of most commonly found air pollutants is summarized as follows:

Pollutant	Effect
Pb	Intellectual and behavioral development problems particularly in children
CO	Vision and manual dexterity impair, Learning ability impair, Angina, Death
SO_2	Respiratory problems in sensitive individuals and asthmatics
NO_x	Lung function problems (especially in asthmatics), Heart disease
O_3	Transient effects on the respiratory system, Decline in pulmonary function
Particles	Changes in lung function, Asthma, Cancer (at specific composition), Death
Toxic gases	e.g.: benzene, polycyclic aromatics, 1,3-butadiene, aldehydes: Cancer

(Colls J., 1997)

II. Mechanisms Causing Health Effects

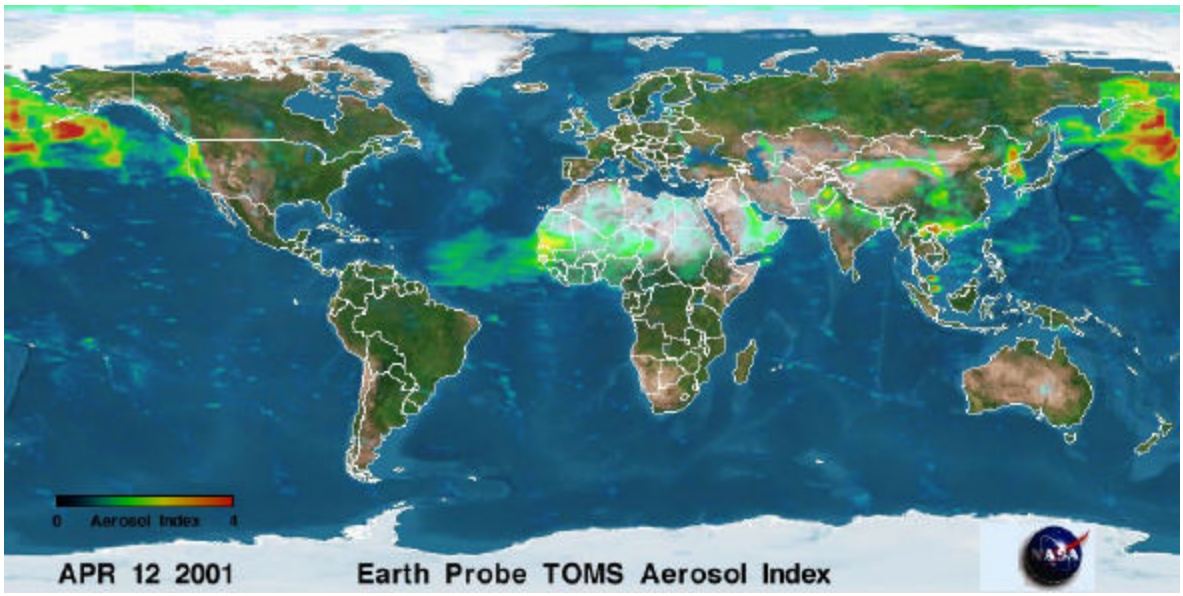
Air pollutants can be found in all three physical phases: solid, liquid or gaseous. When solid or liquid they are called Aerosols or Particles, which, depending on their size (i.e., aerodynamic diameter) can be non-respirable (>10μm), respirable a.k.a. PM_{10} (<10μm) or inhalable a.k.a. $PM_{2.5}$ (<2.5μm). PM_{10} and $PM_{2.5}$ can remain in suspension in the air for hours or days and can be transported by the wind to significant distances. Both particle categories have been shown to cause health effects but the latter (i.e., $PM_{2.5}$) are the most damaging because they can penetrate in much deeper parts of the respiratory tract, namely the alveolar regions of the lungs. Ultra-fine particles (smaller than 0.05 μm) are cleared from the lungs very slowly and penetrate the pulmonary interstitium, where they can cause inflammation.

With respect to their origin and chemical composition, particles can be either “primary”, when directly emitted from the source (e.g., vehicles) or “secondary”, when formed in the atmosphere by in-situ chemical processes on emitted gases (e.g., sulfur and nitrogen oxides transformed into ammonium sulfate and nitrate). Secondary particles are mostly in the $PM_{2.5}$ size category while primary particles can be of any size.

III. Parameters

Due to the previously described health effects, there is a pressing request from both scientists and decision-makers for reliable, spatially aggregated and timely information on air quality and associated indicators. This need inevitably leads to an increasing demand for exploitation of Earth Observation data since satellite-based 'spatial measurements' allow geographically synoptic and physically synthetic views of pollution and pollution-related phenomena, and are extremely flexible for integration with other established environmental monitoring techniques (i.e., ground-based samplings and numerical modeling).

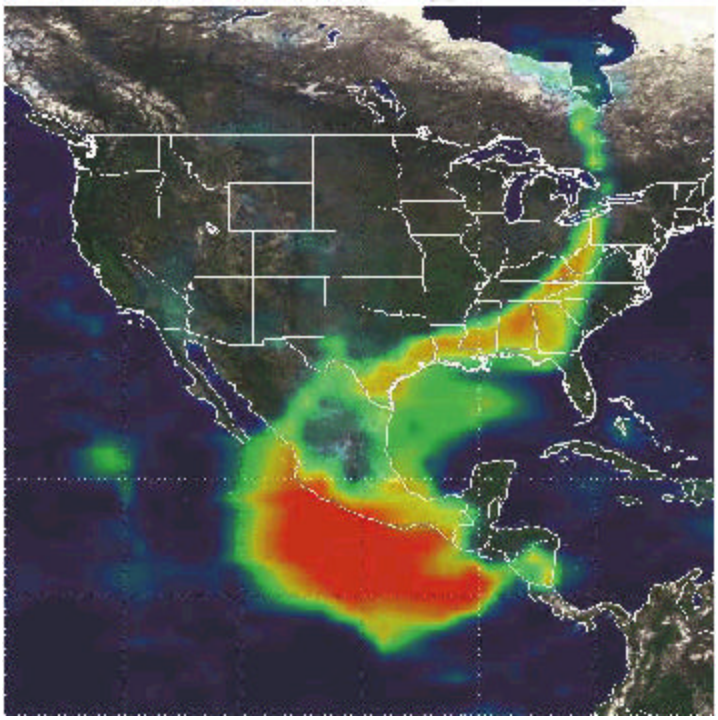
Satellites can assess the optical atmospheric effects induced by the presence of pollutants. These effects can be quantified in terms of aerosol optical thickness (AOT) through their influence on the satellite images. When using visible spectral bands the AOT can be extracted in the visible (AOTV), which, after normalization for the mixing height, can be converted to quasi-surface aerosol loading. AOTV measurements are also linked to the horizontal visibility at ground, which not only is the urban air quality indicator that most people can readily understand but it is also influenced by a number of emissions and air pollutants, mainly the small-sized particles.



IV. Satellite Sensors

Many of the latest ESE and EOS satellite instruments are devoted to the retrieval of atmospheric parameters. Regarding the gaseous pollutants, there are low-resolution measurements for global scale mapping (e.g., by TOMS, GOME, MOPITT, some non-repeatable Shuttle measurements, and instruments on future CHEM and forthcoming European Envisat). Regarding the aerosols, their optical thickness can be retrieved by using low-resolution sensors (e.g., TOMS) for global scale mapping, moderate-resolution sensors (e.g., AVHRR, MODIS, SeaWiFS) for continental to regional scale mapping, and high-resolution sensors (e.g., Landsat, EO-1) for regional to local scale mapping. In

particular, high spatial resolution satellite sensors can sense the optical thickness of particles with diameters approximately between 0.1 and 2.5 µm. Therefore 'pollution maps' produced on the basis of such satellite measurements will provide a reliable indicator for the environmental exposure patterns in densely populated areas. The 'pollution mapping' can be carried out with an optimal resolution of 500m x 500m over cloud-free parts of the satellite images.



Mexican Fire May 16, 1998
Observed by TOMS

V. Data Availability

The production of 'pollution maps' during representative air-pollution conditions is based on time-series of most recent and archived high-resolution ESE satellite data, and the use of newly developed image processing methods. These satellite-based 'pollution maps' provide a general view of how urban pollution spreads and help explain the spatial distribution of particulate pollutants at single but characteristic points in time. This information can be part of an integrated system to help investigate inherent health risks of the urban populations.

- TOMS: http://toms.gsfc.nasa.gov/ Web site provides daily updated data at no charge.
- GOME: http://auc.dfd.dlr.de/GOME/
- MOPITT: http://www.atmosp.physics.utoronto.ca/mopitt/home.html
- AVHRR: http://edc.usgs.gov/
- SeaWiFS: http://seawifs.gsfc.nasa.gov/SEAWIFS.html (images available on-line free of charge for research and educational use)
- Landsat: http://landsat7.usgs.gov/
- EO-1: http://edc.usgs.gov/

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New Technique For Air-Quality Mapping

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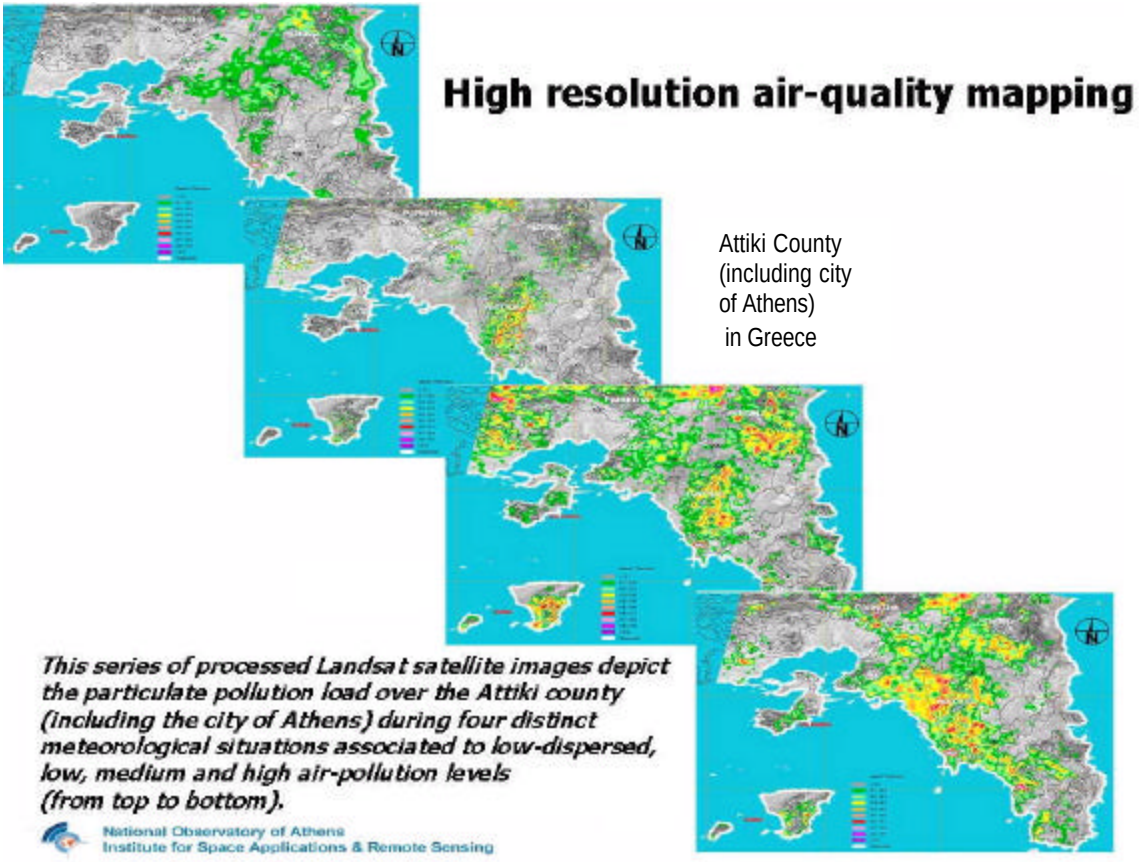

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